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Caucalido platycarpi-Vicietum michauxii – a new weed association from crop fields of Kyrgyzstan (Middle Asia)

Research Article

Sylwia Nowak[1], Arkadiusz Nowak[1]*, Marcin Nobis[2], Agnieszka Nobis[2]

[1]*Department of Biosystematics, Laboratory of Geobotany and Plant Conservation, Opole University, 45-052 Opole, Poland*

[2]*Department of Plant Taxonomy, Phytogeography and Herbarium, Institute of Botany, Jagiellonian University, 31-501 Kraków, Poland*

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Abstract: The study presents the results of geobotanical investigations conducted in crop fields in the western Tian Shan Mts in Kyrgyzstan (Middle Asia). The main research focused on classification of weed communities developing within this poorly investigated area, were conducted in the vicinity of Bishkek and Kara-Balta in 2010. Altogether, 299 phytosociological relevés were sampled using the Braun-Blanquet method. Based on all segetal vegetation patches, the analyses distinguished a new association: Caucalido platycarpi-Vicietum michauxii. The results of these phytosociological studies fill a gap in the knowledge about the syntaxonomical diversity of the Middle Asia region, which is one of the most crucial for segetal weed species. The study shows that anthropogenic agrocoenoses could harbour relatively rich flora. Extensively cultivated fields could especially serve as a suitable habitat for many xerothermophilous and heliophilous plants. More than 75 species in vegetation plots, mainly permament weeds, have been found. There is also a considerable share of species coming over from swards, screes and meadows.

Keywords: *Agrocoenoses • Vegetation ecology • Phytocoenoses • Segetal communities • Turgenio-Roemerietalia • Tian-Shan*

1. Introduction

Middle Asia is a region located in the central part of the Asian continent and comprises several countries such as Kyrgyzstan, Tajikistan and Uzbekistan. In its eastern part, this is a typically mountainous area with several ranges of the Pamirian, Pamir-Alai and Tian Shan mountain systems (Figure 1). Middle Asia is also one of the richest regions as far as plant species diversity in the former Soviet Union is concerned. According to the ten-volume study of the flora of Middle Asia (*Conspectus Florae Asiae Mediae*) [1], more than 8,000 vascular plant species are known from the region. This number is not definitive, as recently some new species have been described from this area [2-10] and new records of its flora have been published [2,11-15]. The flora of Middle Asia is also unique. According to data from the literature on Tajikistan, approx. 30% of the entire flora of vascular plants are generally accepted endemics of the country (endemics s.str. + subendemics) [16-18]. As one of the floristically richest regions in the world, Middle Asia is threatened by a significant climate change, which could result in plant extinction and vegetation degradation [19]. Middle Asia is also regarded as the region most sensitive in the world to climate change, with the near-lowest adaptive capacity to climate instability [20].

Around the globe, research on the flora and vegetation of crop fields has been carried out within a range of contexts and with different intensity. Most studies investigate European agrocoenoses; however, several are focused on the weed vegetation of southwest Asia [21,22]. In last years several studies have been published, focusing on the problem of maintaining agrocoenoses biodiversity in relation to changes in

* *E-mail: anowak@uni.opole.pl*

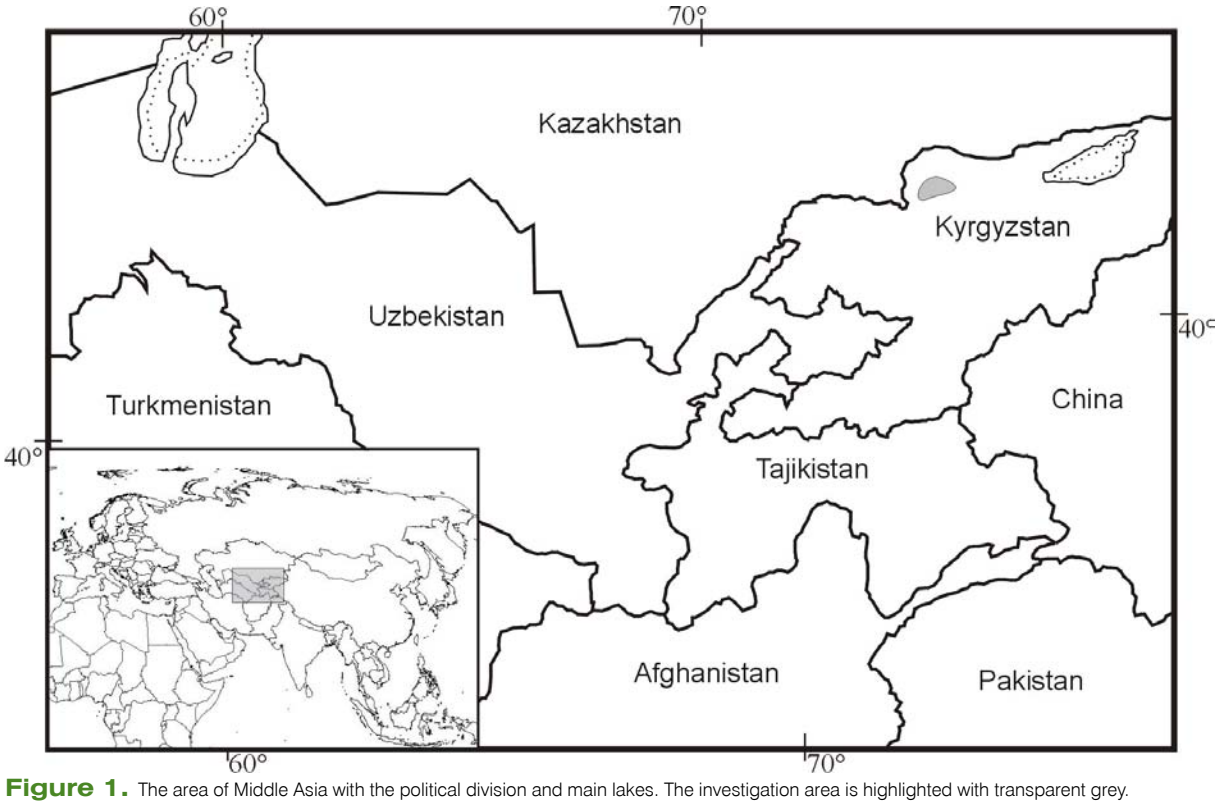

Figure 1. The area of Middle Asia with the political division and main lakes. The investigation area is highlighted with transparent grey.

intensification of crop cultivation. In Asia, as well as in Europe, in all types of plantations, a withdrawal of many field species has been noted due to intensification of agriculture or abandonment of unprofitable crops (especially in mountainous regions) [23,24].

For some regions, relationships between the richness and diversity of vegetation plots, the abundance of weeds in crop phytocoenoses as well as several abiotic factors, like elevation, soil type, climate, *etc*., have been well studied [25-29], along with the surveys concerning the influence of different cultivation methods upon floristic composition of agrocoenoses, richness and diversity of weed communities, and also conservation value of weed flora. In most researches the implementation of modern cultivation techniques is regarded as a main responsible factor of the decreasing weed richness in field phytocoenoses [30-34].

Recently a number of surveys have documented basic records on flora and vegetation for arable field phytocoenoses, with considerable interest to their special role in the conservation of threatened or rare species [35-38]. Also, vanishing and endemic species or plant communities occurring on arable fields as ell as weed habitats other than agrocoenoses have drawn botanists attention in last years [24,39-43]. Additionally, differences in composition of field flora over the period of several years have been studied [44]. The increasing needs in weed conservation gave inspiration and involved botanists in many conservation projects focused on extinct or disappearing taxa [45]. Biological attributes of endangered species of weeds responsible for their regression [46] or expansion [47] have received less attention. Thus it is really surprising that in Middle Asia, one of the most important regions as far as the weed diversity and richness is concerned, hardly any conservation studies focused on weed flora have been conducted.

Recently, only a few papers concerning Middle Asian vegetation classification have been published [48-51], some of them relating to agrocoenoses [52,53].

Agrocoenoses in Middle Asia, probably because their extensive cultivation, are a refuge for many plant species typical for scree, riverbed and sward vegetation in this part of Asia. Abandonment or intensification of their production will probably lead, as has been noted in Europe [23,30], to a decrease in biodiversity and a need for restoration programmes [45]. Therefore, there is an urgent need to document and classify the flora and vegetation of these specific agricultural ecosystems before they undergo possible degradation and impoverishment.

Syntaxonomical investigations of segetal communities have been carried out for several years in many regions of the world, mainly in countries of central Europe [54-60] and Asia [61-63]. As regards

regions with similar macrobioclimatic conditions (Mediterranean, Irano-Turanian geobotanical provinces) useful data regarding agrocoenoses are available, *e.g.* for Afghanistan, Bulgaria, Greece, Italy, Romania, Serbia and Spain [64-71]. Unfortunately there is scarcity of ecological data for those weed species which reached the eastern range limit in Middle Asia and have the centers of occurrence in Saharo-Sindian province [72-74]. Unfortunately to date, in certain regions of Middle Asia, for example in Kyrgyzstan, Kazakhstan, Uzbekistan, no research of plant communities of these field ecosystems has been conducted. Phytosociological research is essential to document the syntaxonomic diversity of these specific phytocoenoses. In Middle Asia they are all the more important because so far there have been no syntaxonomic studies on segetal communities, even though the vegetation there is extremely rich and relatively well preserved due to the low intensity of cultivation. Outside Middle Asia, segetal weed vegetation studies have been conducted for a few areas situated, *e.g.* in Bashkortostan (southern Urals) and Mongolia in Central Asia [62,63,75].

2. Experiments Procedures

2.1 Study area

The main research was conducted in the central part of Middle Asia (Kyrgyzstan and Tajikistan) within an area approx. 350,000 km² (Figure 1). The surveys on Caucalido platycarpi-Vicietum michauxii were done on crop fields between Bishkek and Kara-Balta in northern Kyrgyzstan (Figure 2). This is a typically submontane area, situated at the altitude between 500 and 1,100 m. The northern part of Middle Asia is situated generally in transition zone between the Temperate and Mediterranean macrobioclimates. According to recently published bioclimatic classification of the World, which considers mainly precipitation and temperature values, the study area has to be classified within the Mediterrenean type of macrobioclimate. This type of climate is characterized by a summer drought lasting for at least two consecutive months in which P < 2T [76]. In a case of Bishkek, four months in summer period match this condition (Figure 3). Also other bioclimatic features of the study area classify it to the Mediterranean macrobioclimate: The yearly average temperature is below 25°C (10.3°C) and the Compensated Thermicity Index is below 580 (572.3). Continentality Index is Ic=29, so our study area shows a continental type (eucontinental subtype, weak level). The Ombrotype Index (Io=2.6) confines the study area within the lower dry horizon. According to the thermotypes tresholds, the Bishkek region has to be classified as lower inframediterranean zone. As it is typical for the Mediterranean climate, the area has generally high solar radiation, as well as a low percentage of cloud cover, high-amplitude annual temperatures, low humidity and precipitation, with the exception of the spring period, when there is a considerable amount of rainfall (Figure 3). In the

Figure 2. The schedule map of the study area with main cities, roads and rivers.

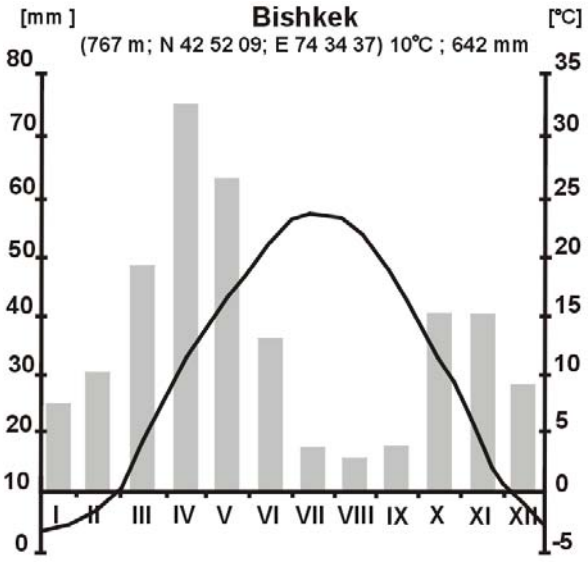

Figure 3. The climatic diagram according to the mean monthly precipitation and temperature values for Bishkek.

research area, average temperatures in June are around 22°C. The annual precipitation here is less than 700 mm. In the alpine zone (the high Tian Shan mountains), the climate is much harsher with average temperatures in July between 10.0 and 13.5°C [77]. Annual precipitation ranges here from about 500 mm on northern slopes to *ca*. 1,000 on southern. The lower limit of perpetual snow in the western Tian Shans is at an altitude of 3,000-3,300 m [78]. This climatic and bioclimatic terms determine the vegetation types and plant formations in the study areas, where evergreen forests and xerothermophilous swards and shrubs dominate in lowlands and in colline belt.

2.2 Data and analyses

During the study 299 vegetation relevés in crop fields of Middle Asia were collected between 2009 and 2012. Among these relevés, 8 samples were made in Kyrgyzstan for the association Caucalido platycarpi-Vicietum michauxii. The size of each vegetation relevé was 30 m^2. In each them, all vascular plant species were recorded according to the cover-abundance-scale of Braun-Blanquet [79]. The seven-degree scale was used (r, +, 1, 2, 3, 4, 5).

All relevés were stored in a database using the JUICE program [80]. A TWINSPAN analysis [81] and detrended correspondence analyses (DCA) were performed with the floristic data set (presence-absence data, no downweighting of rare species) to check the manual floristic-sociological classification and to illuminate the relationships between the groups. For ordination, CANOCO for Windows 4.5 was used [82]. The data from the relevés showed a clear unimodal response, enabling us to perform a Detrended Correspondence Analysis (DCA).

Vegetation classification follows the sorted table approach of Braun-Blanquet [79]. In the analytic table (Table 1), species constancies are given in constancy classes [83]. The new association was described according to the International Code of Phytosociological Nomenclature [84]. The presented association is presented in the syntaxonomical system at the end of the description. In the process of distinguishing the association, the works of Kropáč [85], Hilbig [39] and Wittig *et al.* [74] were taken into account.

Plant names were adopted mainly after Czerepanov [86]. Herbarium collections have been deposited in the Herbarium of Middle Asia Mountains, hosted in OPUN (Opole University, Poland).

3. Results

3.1 Floristical structure of Caucalido platycarpi-Vicietum michauxii

The number of taxa recorded in the relevés totals 75, with 46 taxa exceeding 20% constancy and 18 taxa 60%. The highest frequency was noted for several typical weeds like *Vicia michauxii*, *V. peregrina*, *V. hyrcanica*, *Caucalis platycarpos*, *Roemeria refracta*, *Turgenia latifolia*, *Convolvulus arvensis* and *Lamium amplexicaule*. Not all species noted in relevés are typical for segetal vegetation. There are many ruderal species, namely *Sisymbrium irio*, *Descurainia sophia*, *Cichorium intybus*, *Bromus tectorum*, *Sisymbrium altissimum*, *Galium aparine*, *Ceratocephalus testiculatus* and others as well as plants occurring mainly in scree vegetation, *e.g. Dodartia orientalis*, *Chondrilla aspera*, *Filago minima*, *Trigonella arguata*; xerothermophilous swards (*Ixiolirion tataricum*); or meadows and pastures (*Plantago lanceolata* and *Hypericum perforatum*). Some of the species, *e.g. Lamium amplexicaule* and *Xanthium californicum*, have come over from the neighbouring root fields. There were no observations of species restricted to wetland vegetation, *e.g.* rushes like *Phragmites australis*, *Mentha asiatica*, *Bolboschoenus glaucus* or *Rorippa palustris*, which occur quite often in Middle Asian crop fields due to irrigation. It is also worth noting that there was an insignificant number of neophytes within the studied vegetation patches (*e.g. Galinsoga ciliata*, *G. parviflora*).

3.2 Numerical DCA ordination

The Detrended Correspondence Analysis ordination run for the entire data set clearly segregates the main sample groups (Figure 4). Analysis of the habitat requirements

Successive number of releve	1	2	3	4	5	6	7	8	C
day	5	5	5	5	13	5	6	6	O
Date: month	5	5	5	5	5	5	5	5	N
year	11	11	11	11	11	11	11	11	S
Longitude	424,556	424,556	424,855	424,855	424,830	424,855	430,953	430,953	T
Latitude	740,177	740,177	740,285	740,285	740,256	740,285	742,389	742,389	A
Altitude (m)	993	993	819	819	859	819	589	589	N
Cover of herb layer (%)	70	70	60	50	70	60	75	55	C
Releve area (m^2)	30	30	30	30	30	30	30	30	Y
pH	7.1	7.4	7.8	7.5	7.5	7.5	7.3	7.4	
Number of weeds	25	27	32	30	27	27	28	24	
Cultivated plants									
Secale cereale	3	3	4	4	3	.	2	3	
Hordeum vulgare	.	.	.	.	.	3	.	.	
ChAss. Caucalido-Vicietum									
Vicia michauxii	+		+	1	1	+	+	+	V
Caucalis platycarpos	+	+	1	+	+	+	+		V
ChAll. Aveno trichophyllae-Euphorbion falcatae									
Vicia hyrcanica	+	+	2	1	1	1	1	+	V
Vicia peregrina	+	+	+	+	1	1	+	.	V
Ranunculus arvensis	3	2	2	1	3	+	.	.	IV
Cnicus benedictus	+	+	.	.	+	.	.	+	III
Heterocaryum szovitsianum	.	.	.	.	.	.	2	+	II
Euphorbia falcata	.	.	+	.	.	+	.	.	II
Sporadic species*: Centaurea depressa* 8(1).									
ChO. Turgenio-Roemerietalia refractae									
Roemeria refracta	1	1	.	+	+	2	2	1	V
Turgenia latifolia	+	1	1	2	1	.	+	1	V
Galium spurium	.	+	+	+	+	.	+	+	IV
Lepyrodiclis holosteoides	.	+	.	+	.	.	+	2	III
Vaccaria hispanica	.	.	1	+	+	.		.	II
Vicia sativa	+	.	+	+	.	.	.	.	II
Fumaria vaillantii	.	.	+	.	.	+	.	.	II
Asperugo procumbens	.	.	.	+	.	.	.	+	II
Sporadic species: *Brassica campestris* 6(r); *Cirsium incanum* 7; *Galium tricornutum* 5; *Scandix pencten-veneris* 2; *Sinapis arvensis* 2.									
ChCl. Stellarietea mediae									
Convolvulus arvensis	+	1	+		+	1	1	+	V
Lamium amplexicaule	+	1	+	+	+	1	.	+	V
Veronica arguteserrata	1	1	+	1	+	.	+	.	IV
Capsella bursa-pastoris	+	.	.	+	+	+	+	1	IV
Veronica polita	.	.	1	+	+	.	+	+	IV

Table 1. Caucalido platycarpi-Vicietum michauxii ass nova in Kyrgyzstan.

Lithospermum arvense	+	+	+	+	.	.	.	.	III
Goldbachia torulosa	.	+	.	.	.	.	1	+	II
Fallopia convolvulus	.	.	+	+	+	.	.	.	II
Sisymbrium altissimum	.	.	+	.	.	+	+	.	II
Veronica persica	.	.	.	+	+	.	.	+	II
Euclidium syriacum	.	.	.	.	.	.	2	1	II
Lactuca serriola	+	+	.	.	.	.	.	.	II
Lycopsis orientalis	.	.	.	.	+	.	+	.	II
Sporadic species: *Artemisia annua* 7(1); *Atriplex hastata* 1; *Camelina sylvestris* 8; *Cerastium perfoliatum* 4; *Polygonum aviculare* 7; *Tauscheria lasiocarpa* 7(1); *Xanthium californicum* (*italicum*) 5.									
Others									
Ceratocephalus testiculatus	2	2	+	+	1	1	1	1	V
Litwinowia tenuissima	+	+	.	+	+	.	+	+	IV
Thlaspi perfoliatum	.	.	1	1	+	2	.	+	IV
Alyssum desertorum	+	+	+	+	.	1	.	.	IV
Descurainia sophia			+	+	.	r	+	+	IV
Polygonum persicaria	+	+	.	.	.	+	1	.	III
Dodartia orientalis	1	+	.	.	.	+	.	.	II
Cardaria repens	.	.	+	+	.	.	.	1	II
Poa bulbosa	+	+	+	.	.	.	.	.	II
Ixiolirion tataricum	+	+	.	.	.	+	.	.	II
Viola occulta	.	.	+	+	.	+	.	.	II
Stellaria neglecta	.	.	+	.	+	.	.	+	II
Veronica verna	.	.	+	.	1	.	.	.	II
Myosotis stricta	+	.	+	.	.	.	.	.	II
Bromus tectorum	.		+		+	.	.	.	II
Arenaria serpyllifolia	.	.	+	.	.	+	.	.	II
Marrubium vulgare	.	.	.	.	.	+	+	.	II
Sporadic species: *Bromus scoparius* 2; *Chondrilla aspera* 4; *Filago minima* 7; *Galium aparine* 4; *Geranium rotundifolium* 4; *Holosteum glutinosum* 3; *Holosteum umbellatum* 5; *Hypericum perforatum* 6; *Malva neglecta* 6; *Medicago sativa* 2; *Onopordum acanthium* 7; *Plantago lanceolata* 6; *Potentilla orientalis* 1; *Sewerzovia turkestanica* 2; *Sisymbrium irio* 3; *Trigonella arcuata* 6.									

continued **Table 1.** Caucalido platycarpi-Vicietum michauxii ass nova in Kyrgyzstan.

and floristic structure of these phytocoenoses shows that the factor responsible for these dissimilarities is humidity. The left part of the diagram is occupied by the relevés from the relatively driest habitats, the centre by those from relatively wet areas, and the right by the samples from the most humid areas in the highest mountainous elevations or from wetland habitats in the river valley bottoms. The vertical gradient, from the lower to the upper part of the diagram, seems to be mostly related to soil structure and the amount of gravel and sand in the soil profile. The samples located in the upper part of the biplot were taken in sandy or gravel rich soils. Caucalido platycarpi-Vicietum michauxii is a relatively well-distinguished association and occupies the upper-central part of the diagram, where samples typical for relatively fertile and moisture (fresh) soils and medium elevations (mainly between 800 to 1,000 m a.s.l.) are concentrated. The reason for the distinctiveness of these central phytocoenoses' patches revealed by the correspondence analyses is, of course, essential differences in floristic composition and structure.

3.3 Description of Caucalido platycarpi-Vicietum michauxii ass. nova

Diagnostic species: *Vicia michauxii*, *Caucalis platycarpos*

This association prefers relatively low altitudes, mostly between 600 and 900 m. Patches of the phytocoenoses were found on the foothills, gently falling to the north, of the Tian-Shan range. It develops on loose, clayey, alkaline,

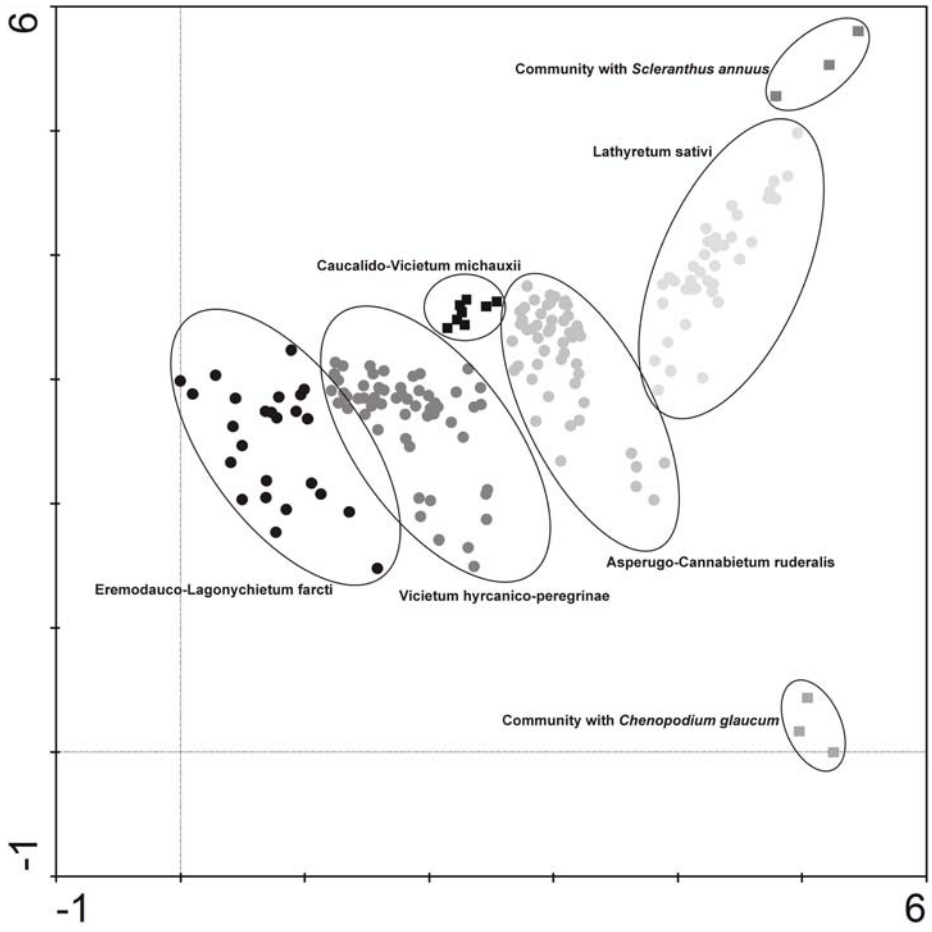

Figure 4. DCA ordination for all samples (N=299) with indication of Caucalido platycarpi-Vicietum michauxii (■) on the background of other samples of other segetal phytocoenoses known from Middle Asia.

fertile and fresh soils and is relatively rich in species. In a single patch, between 25 and 32 taxa were noted. The average number of species per relevé is 28. The total cover value of weed species in the phytocoenoses does not exceed 65%, and, in most cases, was ca. 35-40%. Among the most constant and frequently contributing species are: *Vicia michauxii, Caucalis platycarpos*, *Vicia hyrcanica*, *Thlaspi perfoliatum*, *Litvinovia tenuissima*, *Vicia peregrina*, *Ixiolirion tataricum, Alyssum desertorum* and *Ranunculus arvensis*. Both main diagnostic species belong to the rarest elements of Middle Asian flora; consequently, the association is likewise rather infrequent. Because the range of the diagnostic species (especially *Vicia michauxii*) is much larger than northern Kyrgyzstan, it is supposed that the association is also present in other regions of Middle Asia, *e.g.* Tajikistan [87].

3.4 Syntaxonomical position of the association

The plots of Caucalido-Vicietum association appears exclusively on crop fields in central part of Middle Asia which determines its syntaxonomical position within the *Stellarietea mediae* class.

Class: Stellarietea mediae Tüxen *et al.* ex von Rochov 1951
Ord.: Turgenio latifoliae-Roemerietalia refractae S. Nowak *et al.* 2013
All.: Aveno trichophyllae-Euphorbion falcatae S. Nowak *et al.* 2013
Ass.: Caucalido platycarpi-Vicietum michauxii ass. nova (holotypus hoc loco Table 1, rel. 4)

4. Discussion

Being one of the world's richest regions in flora, Middle Asia should also have a significant number of weed species along with their communities. Surprisingly, despite being so rich in weed species, the Middle Asia has not drawn considerable attention of botanists so far, and only few studies concerning segetal flora

have been published for that region long time ago [*e.g.* 88]. To find out research needs for agrocoenoses and delimit the most interesting study areas in Middle Asia, a reconnaissance studies and a herbarium and literature query were conducted by authors in the years 2008-2011. We found out that even for relatively small areas, *e.g.* Tajikistan, the segetal flora consists of almost 700 taxa. The most weed-rich regions of Middle Asia are the southwestern areas of Tajikistan and central part of the region - the Fergana Valley where over 500 species have been observed [89]. Relatively rich in species are also the plots of Caucalido-Vicietum from northern Kyrgyzstan. Despite their location on the outskirts of a warm mediterranean climate zone, samples with more than 30 species have to be regarded as significantly rich in segetal species when compared to other crop cultivation areas in the world [*e.g.* 21,22,25,39,58,60,71,90].

The specificity of soil substrate (gravel-sandy soils and alkaline pH) and the floristic structure of the community patches clearly separate the Caucalido-Vicietum samples from other segetal vegetation plots (see Figure 4). After recent phytosociological studies completed in Tajikistan [53] the position of the association within the syntaxonomical system is quite clear. Due to the considerable differences between the dominant species of the Middle Asian and European crop communities, a new vegetation order and alliance were proposed (Turgenio latifoliae-Roemerietalia refractae and Aveno trichophyllae-Euphorbion falcatae). Most species making up the described community originated from Middle Asia or the Irano-Turanian phytogeographical province, with only a few coming from the Eurosiberian range. As diagnostic for the order, taxa relatively often occurring in cereals, *Turgenia latifolia* and *Roemeria refracta*, have been chosen (Table 1). Within the order, the alliance of Aveno trichophyllae-Euphorbion falcatae was singled out. This includes the phytocoenoses of warm places on alkaline substrates in Middle Asia, influenced by a mediterranean or submediterranean climate. Species proposed as diagnostic for this alliance are *Vicia hyrcanica*, *V. peregrina*, *Ranunculus arvensis*, *Cnicus benedictus*, *Heterocaryum szovitsianum* and *Euphorbia falcata*. All of these species, occurring with high constancy and relatively significant abundance, have built up the community and distinguished it from the geographical vicariant Caucalido-Scandicetum from Europe and northwestern Asia [25,53,57,59,60]. Obviously, the final syntaxonomical classification of the segetal communities of Middle Asia requires further phytosociological studies.

Analyses of the chorology of the main diagnostic species for the association show that the potential range of Caucalido platycarpi-Vicietum michauxii includes the area of central and northern Tajikistan, eastern Uzbekistan and southern Kyrgyzstan as well as the northern limits of the Irano-Turanian and Mediterranean provinces. The suitable climate and alkaline soils within the great river valleys, with considerable amounts of gravel and sand, could harbour Caucalido platycarpi-Vicietum michauxii in many sites. However, until now, despite the penetration of many areas (*e.g.* in Uzbekistan, Tajikistan and Kyrgyzstan), phytocoenoses of Caucalido platycarpi-Vicietum michauxii have not been found. It is supposed that *Vicia michauxii* as the main diagnostic species of the association, due to the intensification of cultivation methods, is under significant anthropogenic pressure in Middle Asia.

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